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ORIGINAL

FLOOD INSURANCE STUDY

COMPLETED

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CITY OF TRAVERSE CITY, MICHIGAN

GRAND TRAVERSE COUNTY

JUNE 15, 1982

Federal Emergency Management Agency

COMMUNITY NUMBER - 260082

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Flood Boundary and Floodway Map

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Flood Insurance Rate Map

FLOOD INSURANCE STUDY

CITY OF TRAVERSE CITY,
GRAND TRAVERSE COUNTY, MICHIGAN

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the City of Traverse City, Grand Traverse County, Michigan, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study will be used to convert the City of Traverse City to the regular program of flood insurance by the Federal Emergency Management Agency (FEMA). Local and regional planners will use this study in their efforts to promote sound flood plain management.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than those on which these Federally-supported studies are based. These criteria take precedence over the minimum Federal criteria for purposes of regulating development in the flood plain, as set forth in the Code of Federal Regulations at 44 CFR, 60.3 (d). In such cases, however, it shall be understood that the state (or other jurisdictional agency) shall be able to explain these requirements and criteria.

1.2 Authority and Acknowledgements

The source of authority for this Flood Insurance Study is the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

This Flood Insurance Study was conducted by the U.S. Army Corps of Engineers (COE), Detroit District, for the Federal Emergency Management Agency, under Inter-Agency Agreement No. IAA-H-9-79, Project Order No. 21. The hydrologic and hydraulic analyses were performed by Gannett Fleming Corddry and Carpenter, Inc., for the COE, under Contract No. DACW-35-80-C-0025. This study was completed in March 1981.

The information presented for Mitchell Creek was taken from the "Flood Hazard Study Report for Mitchell Creek" prepared by the U.S. Department of Agriculture, Soil Conservation Service (SCS) (Reference 1).

1.3 Coordination

Flooding sources requiring detail and approximate study were identified in a meeting attended by personnel of the Michigan Department of Natural Resources, the Detroit District COE, FEMA and representatives of the City of Traverse City on November 14, 1978.

Upon initiation of the study, a legal notice was placed in the Traverse City Record-Eagle during April 1980 to notify all interested persons to submit any relevant facts and technical data concerning local flood hazards.

The U.S. Geological Survey (USGS) office in Lansing, Michigan was contacted and provided information on stage-discharge relationships and other recorded data which was used in the analysis of the Boardman Lake stages and the Boardman River discharges. The Detroit District COE provided data on Grand Traverse Bay lake levels. The SCS and the Traverse Bay Regional Planning Commission also provided the Study Contractor with information. Updated field survey data and aerial mapping for this study were collected and prepared by Abrams Aerial Survey Corporation of Lansing, Michigan in 1980.

The technical aspects of the study were coordinated with, reviewed and approved by the Michigan Department of Natural Resources (MDNR), the state-coordinating agency.

On January 12, 1982, the results of the work by the Study Contractor were reviewed and accepted at a final coordination meeting attended by representatives of the Study Contractor, FEMA, and the community.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated area of the City of Traverse City, Grand Traverse County, Michigan. The area of study is shown on the Vicinity Map (Figure 1).

The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development or proposed construction for the next five years, through March 1986.

Approximate methods of analysis were used to study those areas having a low development potential or minimal flood hazards as identified at the initiation of the study. The scope and methods of study were proposed to and agreed upon by FEMA and the City of Traverse City.

The limits of detailed and approximate studies in the community were determined by FEMA in consultation with the Detroit District COE and representatives of the City of Traverse City during a meeting held in November 1978. The areas studied by detailed methods include 3.3 miles of shoreline along the West Arm of Grand Traverse Bay, extending from the Township of Elmwood - Traverse City boundary to the Old Mission peninsula; 1.3 miles of shoreline along the East Arm of Grand Traverse Bay at the southeastern end of the Old Mission peninsula; 1.6 miles of the Boardman River extending from its mouth at the West Arm of Grand Traverse Bay to the Boardman Lake dam site; the Boardman Lake shoreline extending from the dam site to the southern corporate limits of Traverse City; 0.8 mile of Kid's Creek extending from its mouth at Wadsworth Street where it empties into the Boardman River to a point immediately southwest of the

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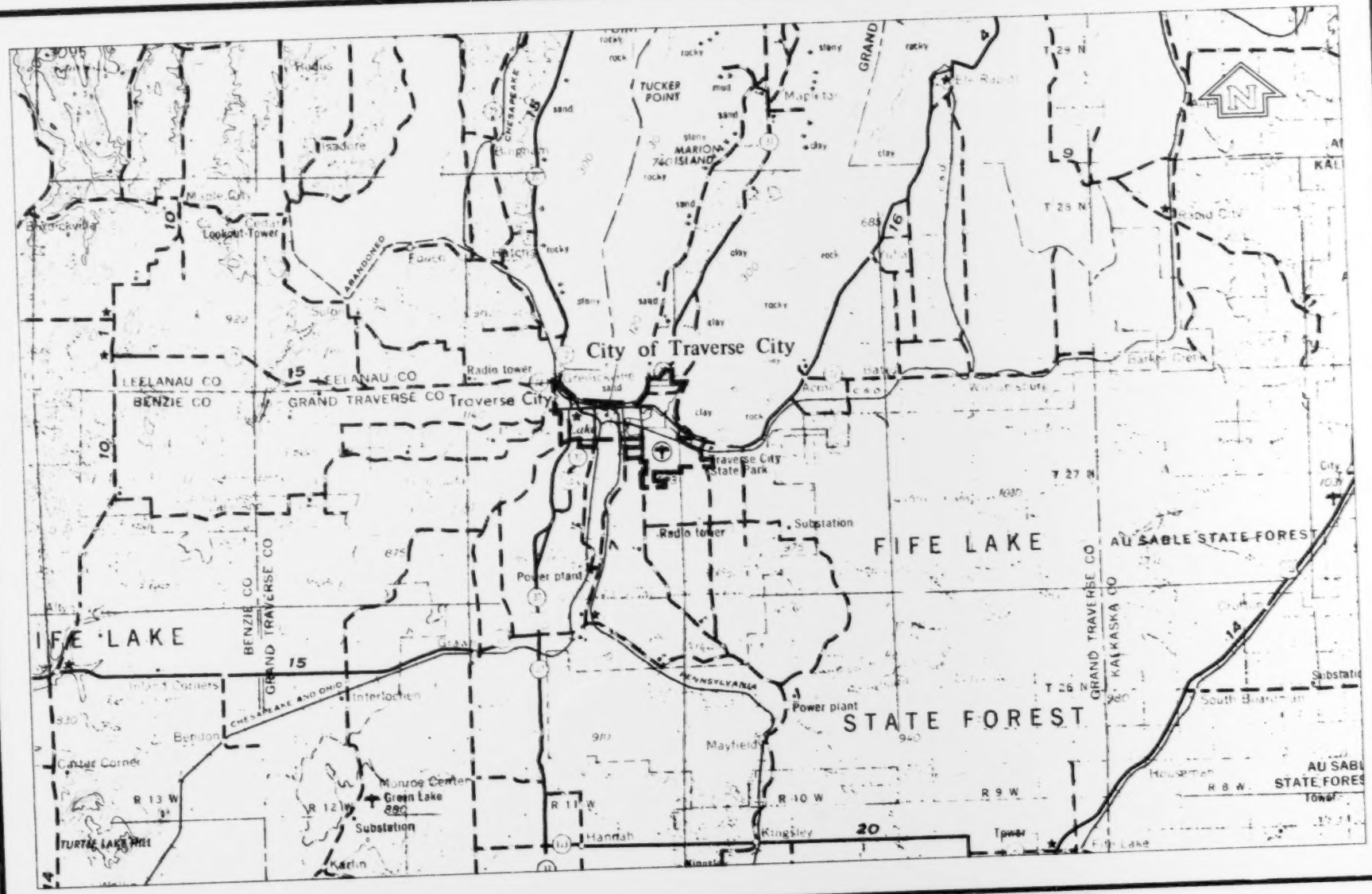

FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF TRAVERSE CITY, MI
(GRAND TRAVERSE CO.)

APPROXIMATE SCALE

4 0 4 8 12 MILES

VICINITY MAP

intersection of Division and Seventh Streets; and 0.7 mile of Tributary A to Kid's Creek extending from its mouth at a point immediately southwest of the intersection of Division and Seventh Streets where it empties into Kid's Creek, then west and north to Front Street near the western corporate boundary of Traverse City.

Also, the areas of Mitchell Creek and the East Branch Mitchell Creek affecting the City of Traverse City were taken from the SCS report (Reference 1) and added to this report.

Approximate methods of flood plain delineation were used to study 1.2 miles of Kid's Creek extending south from the upstream limit of Kid's Creek detail study to the corporate limits.

2.2 Community Description

The City of Traverse City is located in north-central Grand Traverse County in the northwestern part of the Lower Peninsula of Michigan. The corporate boundaries of the City of Traverse City are defined by the Township of Elmwood, the West Arm of Grand Traverse Bay and the Township of Peninsula to the north; the East Arm of Grand Traverse Bay to the east; the Township of East Bay to the south and east; and the Township of Garfield to the south and west. The total area contained within the city is 7.0 square miles. According to 1970 Census figures, the population of the City of Traverse City is 18,048, which represents a 2.1 per cent decrease below the 1960 population of 18,432 (Reference 2).

The major transportation arteries serving the community are U.S. Highway 31, State Highways 37, 22, and 72, the Chessie System and Conrail. The Cherry Capitol Airport provides Traverse City with air transportation service.

The local economy in Traverse City is influenced substantially by tourism, cherry production and exports, commercial and recreational nautical traffic, and service-related industries. Traverse City is the cherry capitol of the United States with nearly 50 per cent of the world's cherry production taking place in this region. Cherry exports in 1978 totalled $90 million. The Interlochen Center for the Arts, located 15 miles southwest of Traverse City, attracts public audiences to the area for year-round performances by talented young artists. A Federal navigation harbor project consisting of breakwaters and an anchorage basin for light-draft commercial and recreational craft was completed by the COE in 1966. The project is located just north of Traverse City at Greilickville in the Township of Elmwood on the West Arm of Grand Traverse Bay (References 3 and 4).

The climate in Traverse City is dependent upon wind direction. The prevailing westerly winds passing over Lake Michigan create a moderation in annual temperature variations. Cool lake water cools warm air reaching the city in the spring, and the warm lake water warms the cool air reaching the area in the fall. The climate during periods of prevailing westerly winds is quasi-maritime. When the wind shifts to the south of southeast and passes over a large land mass, the climate becomes modified continental with more abrupt variations in temperature.

The average annual daily maximum and minimum temperatures in Traverse City are 55 degrees Fahrenheit (F.) and 37 degrees F., respectively. The average annual precipitation is 29.1 inches (Reference 5).

Topography in Traverse City varies from rolling terrain with steep slopes along the southwestern and western edge of the city to level to gently sloping in the remainder of the city. The elevations in the community range from 580 feet National Geodetic Vertical Datum (NGVD) along the Grand Traverse Bay shoreline, to 740 feet NGVD near Hickory Hill in the northwestern part of the city.

The geomorphic characteristics of the region are a result of several periods of glaciation, with the most recent being the Wisconsin stage which receded about 10,000 to 12,000 years ago. Therefore, geologically speaking, the formation of the land in the region is very recent and correspondingly, the drainage patterns are in the early stages of development. This results in a branching or dentritic drainage system which drains slowly and has a high potential for flooding storage.

The soils in the flood plains along the East and West Arms of Grand Traverse Bay and along the Boardman River downstream of Front Street are Lake Beach and Eastport sands which are nearly level to gently sloping and interspersed with a few stones and boulders. The soils along the bay shorelines are subject to wave action which constantly reworks and sorts the soil and washes new sediment onto the beach. The soil along the Boardman River flood plain upstream of Front Street and downstream of the Boardman Lake dam site near Cass Street, and along the Kid's Creek flood plain from its mouth near Wadsworth Street to the upstream detail study limit just south of Seventh Street, is predominantly Roscommon mucky loamy sand which is poorly drained and nearly level.

The soil along the Boardman Lake flood plain is predominantly well drained East Lake Mancelona loamy sand with slopes ranging from nearly level to very steep. The soil in the Kid's Creek approximate study flood plain is Edwards Muck which is level, poorly drained organic soils underlain by marl. East Lake Mancelona, Edwards Muck and organic Tawas Roscommon Complex soils are in the flood plain along Tributary A to Kid's Creek (Reference 5).

Grand Traverse Bay is a U-shaped extension of Lake Michigan. The principal axis of the bay is in a north-south direction and 30 miles long. The East and West Arms of Grand Traverse Bay in Traverse City, which are being studied by detailed methods, are divided by the Old Mission peninsula which extends northward from Traverse City into the bay.

The land uses along the East Arm of Grand Traverse Bay shoreline in Traverse City are approximately 60 per cent residential and commercial and 40 per cent recreational and beaches. The land uses along the West Arm of Grand Traverse Bay are approximately 15 per cent residential and commercial and 85 per cent recreational and beaches.

Kid's Creek is also known as Aslyum Creek and Hospital Creek. The Kid's Creek watershed drains 7.0 square miles and is approximately 2.7 miles wide and 4.5 miles long. About 14 per cent of the watershed lies within the Traverse City limits with the remainder lying in the Township of Garfield.

The land uses along the Kid's Creek detail study reach are approximately 10 per cent commercial, 10 per cent idle and 80 per cent residential. The land uses along the Kid's Creek approximate study reach are approximately 20 per cent residential, 75 per cent idle and five per cent commercial.

Tributary A is one of many small tributaries to Kid's Creek. Its drainage area is 1.5 square miles at its confluence with Kid's Creek and encompasses the northern portion of the Kid's Creek watershed.

The land uses along Tributary A are approximately 10 per cent commercial, 15 per cent idle and 75 per cent residential.

Boardman Lake has a drainage area of 276 square miles at its upstream end where the Boardman River empties into it. The level of Boardman Lake and the outflow to Boardman River is controlled by outlet works at a dam site located between Cass and Union Streets in Traverse City. The minimum top of dam elevation is approximately 5.1 feet above the normal upstream water-surface elevation and the dam is 182 feet wide. Downstream of the dam, the Boardman River flows northwest through Hannah Park for approximately 1,900 feet to just south of Front Street where it bends in a U-shape and flows approximately 4,000 feet in a northeast direction to its mouth on the West Arm of Grand Traverse Bay.

The land uses along Boardman Lake are approximately 10 per cent residential, 40 per cent idle and 50 per cent commercial and industrial. The land uses along the Boardman River are approximately 35 per cent recreational, 10 per cent residential and 55 per cent commercial and industrial.

2.3 Principal Flood Problems

The history of flooding on the streams, lake and bays within the community indicates that flooding may occur during any season of the year, although the worst flooding conditions are normally the result of spring rains combined with snowmelt.

Lake level gage data on Grand Traverse Bay is recorded seasonally, from approximately April to October. The highest lake levels occur during this period of time, although rises of a lesser magnitude can be expected to occur at various times during the year.

Past floods on Kid's Creek have affected the area along Cedar Street between Seventh and Sixth Streets. Cedar Street is subjected to periodic flooding and some residential property damage has occurred. Other portions of the flood plain are flooded less frequently, but a potential for damage from larger flood events does exist. Past floods on Tributary A have damaged several residences, commercial and professional buildings west of Elmwood Street (Reference 6).

The following newspaper accounts describe past flooding events on Kid's Creek and Tributary A:

"In 1969 and again in 1970, flash floods submerged parts of the (Munson) medical center and the neighborhood around Cedar Street, causing thousands of dollars in property damage....." (Traverse City Record Eagle, April 28, 1980).

"On July 11, (1972), in the middle of the National Cherry Festival, the rains came in torrents. That night an estimated 800 tons of soil washed into the creek, killing almost every living thing in its path. The (Munson) medical center was saved from flooding when emergency earthen dikes were hastily built up around it,....." (Traverse City Record Eagle, April 28, 1980).

Figures 2-7 show past flooding which has occurred at various locations in the Kid's Creek flood plain.

No flooding damage has been documented on Boardman Lake, Boardman River or the East and West Arms of the Grand Traverse Bay, although interviews with local residents indicate that fluctuations in Grand Traverse Bay lake levels and beach erosion cause minor problems along bay shoreline areas. Shoreline erosion is due primarily to storm induced waves. High water levels can cause acceleration of shore erosion by inundating beaches and allowing wave action to reach the bluffs. High water levels occur over protracted periods of above-normal precipitation, when drainage into Lake Michigan exceeds the flow out of it. High water levels can also occur on the downwind shore of the lake during severe windstorms.

2.4 Flood Protection Measures

With the exception of a culvert enlargement project in Traverse City along Kid's Creek and Tributary A, which enhances the hydraulic carrying capacity of the streams, no flood protection devices exist within the city. Retention ponds have been constructed along U.S. Highway 31 and in recently developed commercial areas along Kid's Creek, but these only serve the purpose of minor water impoundments, as opposed to flood control structures. Concrete channel retaining walls exist along the Boardman River in developed overbank areas. The Boardman Lake dam is functional in maintaining a pool elevation upstream, but was not designed as a flood control structure. Breakwaters and rip-rap shoreline areas along the Grand Traverse Bay serve to minimize beach erosion, but do not offer protection from flooding.

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FIGURE 2 - Looking west from Cedar Street across private bridge, approximately 50 feet downstream of Cedar Street south crossing. Photo was taken on July 11, 1972 after a two-inch storm. (Photo courtesy of Traverse Bay Regional Planning Commission)

FIGURE 3 - Downstream view of private bridge shown in Figure 2, showing flooding along west side of Cedar Street after a two-inch storm on July 11, 1972. (Photo courtesy of Traverse Bay Regional Planning Commission)

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FIGURE 4 - North side of culvert on 11th Street after a two-inch storm on July 11, 1972. (Photo courtesy of Traverse Bay Regional Planning Commission)

FIGURE 5 - Water ponded south of 11th Street on State Psychiatric Hospital grounds. (November 1978, Photo courtesy of Traverse Bay Regional Planning Commission)

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FIGURE 6 - Water across Elmwood Street, looking north from Silver Lake Road towards 11th Street. (November 1978, Photo courtesy of Traverse Bay Regional Planning Commission)

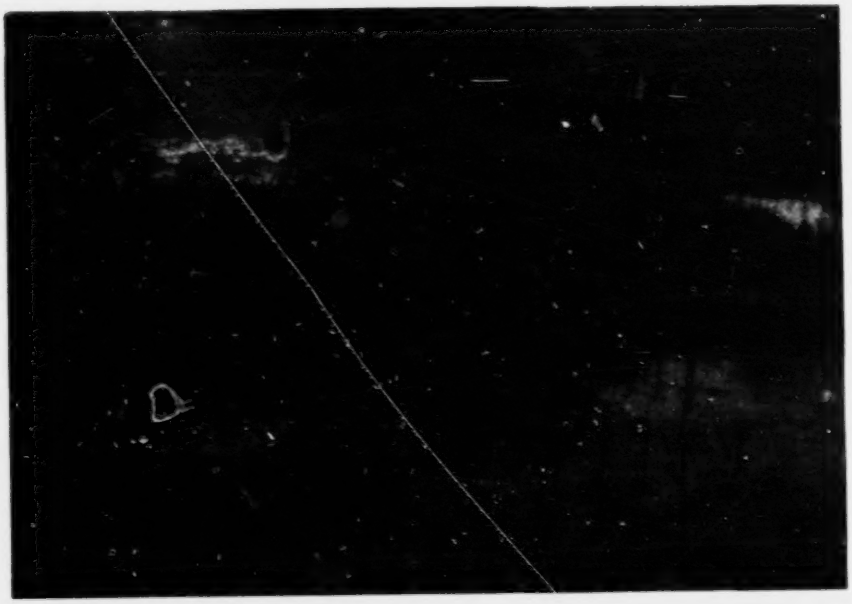

FIGURE 7 - Ponding at upstream end of State Highway 37 just south of upstream limits near Meijer Thrifty Acres. (1972, Photo courtesy of Traverse Bay Regional Planning Commission)

Approximately 70 acres of public land, just south of the Traverse City State Hospital, is planned to be set aside in a natural state as part of a Traverse City land-use management plan for the Kid's Creek watershed. The Township of Garfield has proposed a comprehensive land-use plan which would restrict development in sensitive watershed areas in an effort to control stormwater runoff to Kid's Creek.

Nonstructural measures of flood protection are being utilized to aid in the prevention of future flood damage. These are in the form of land use regulations which control building within areas that have a high risk of flooding. Chapter 14 and Chapter 16 of the Traverse City Zoning Ordinance dated 1976 pertain to these regulations.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equalled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance premium rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 per cent chance, respectively, of being equalled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than one year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (one per cent chance of annual occurrence) in any 50-year period is about 40 per cent (four in ten), and for any 90-year period, the risk increases to about 60 per cent (six in ten). The analyses reported here reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for floods of the selected recurrence intervals for each flooding source studied in detail affecting the community.

For the detailed study of Boardman Lake, recorded discharge data from the USGS gaging station at Mayfield, Michigan was used. The period of record used included water years 1953 thru 1978, inclusive. A log-Pearson Type III frequency analysis was performed on the data using a computed station skew coefficient. A graphical analysis of maximum annual peak discharges plotted according to median plotting position values was used to verify the results (Reference 7). The resulting peak discharges were transferred downstream to Boardman Lake by means of a drainage area ratio exponent (Reference 8).

The MDNR coordinated the elevation-frequency relationships on Boardman Lake and the discharge-frequency relationships for the Boardman River. Synthetic inflow hydrographs into Boardman Lake were developed and

routed through the dam site using the TR-20 computer program (Reference 9). The peak discharges of the inflow hydrographs were derived from the Mayfield gage frequency curve. In addition, the hydrograph of the flood of record at the Mayfield gage (September 1961) was reviewed and the hydrologic model was adjusted to insure that the synthetic inflow hydrograph into Boardman Lake reflects actual basin characteristics.

Field surveys were performed to ascertain outlet conditions and other physical parameters of the Boardman Lake dam site. Existing topographic mapping (Reference 10) was used to compute elevation-storage relationships.

For the detailed study of Boardman River, the four frequency discharges were obtained from the outflows resulting from the routing procedure through the Boardman Lake dam.

For the detailed study of Mitchell Creek and East Branch Mitchell Creek, channel flood routings to establish peak discharge-frequency relationships were made using the SCS TR-20 Hydrology Program and U.S. Department of Agriculture computer facilities (Reference 1). An important storage area exists just upstream of the Chessie System fill on East Branch Mitchell Creek and this causes a reduction in the discharge downstream of the fill.

The discharges for Kid's Creek and Tributary A were based on those presented in the 1973 Kid's Creek watershed study performed by the SCS (Reference 6), with adjustments made to reflect current conditions within the watershed. The adjustments procedure assumes that within the boundaries of the original SCS study, a linear relationship exists between per cent development in the watershed and discharge. The flood profiles presented in the SCS report were reviewed by the Hydrologic Survey Division, MDNR and recommended for use in implementing flood plain ordinances.

Elevation-frequency relationships used in the detailed study of the East and West Arms of Grand Traverse Bay were provided by the Detroit District COE. The flood elevations for the bay at Traverse City were taken from Report on Great Lakes Open Coast Flood Levels (Reference 11).

Due to the physical connection of Grand Traverse Bay to Lake Michigan, an analysis was made to determine if further adjustment to open coast flood levels to include wind setup in the bay was needed. Two methods were used. The first method employed equation 3-97 of the U.S. Army Coastal Engineering Research Center's "Shore Protection Manual" Volume I, dated 1977 (Reference 12). The second method employed equation 5-12 from "Estuary and Coastline Hydrodynamics" (Reference 13).

The results of the analysis indicated that additional wind setup in the bay would be insignificant based on an evaluation of wind speed, wind direction, length of fetch and depth of water. The analysis showed that the extreme depth of Grand Traverse Bay moderates the effects of wind setup. In addition, the orientation of the longer fetches of Lake Michigan to the mouth of the bay are such that significant compounding of wind setup effects would not occur. The open coast elevations presented in Report on Great Lakes Open Coast Flood Levels were, therefore, adopted for this study.

The discharge-frequency and elevation-frequency relationships for the detail study reaches are shown in Tables 1 and 2.

Flood discharges for Kid's Creek, studied by approximate methods, were based upon the discharges presented in the 1973 SCS report on the Kid's Creek watershed for the reach from Eleventh Street upstream to the southern corporate limits, with adjustments made to reflect current conditions in the watershed.

TABLE 1 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (SQ MILES)	PEAK DISCHARGE (CFS) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
BOARDMAN RIVER					
At Union Street Dam	276	1,220	1,650	1,815	2,360
KID'S CREEK					
At mouth	7	175	292	331	415
TRIBUTARY A					
At Sixth Street	0.5	31	71	85	113
At mouth	1.5	54	123	148	197
MITCHELL CREEK					
Outlet at East Arm Grand Traverse Bay	14.67	230	345	390	460
At Townline Road	6.92	135	275	345	475
EAST BRANCH MITCHELL CREEK					
At confluence with Mitchell Creek	9.04	120	170	195	220
At divergence with Mitchell Creek	8.95	155	320	400	575

TABLE 2 - SUMMARY OF ELEVATIONS

LOCATION	ELEVATIONS (NGVD) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
BOARDMAN LAKE	591.0	591.7	592.1	592.9
WEST ARM GRAND TRAVERSE BAY	582.7	583.7	584.0	584.7
EAST ARM GRAND TRAVERSE BAY	582.7	583.7	584.0	584.7

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of the streams in the community were carried out to provide estimates of the elevations of the floods of the selected recurrence intervals along each flooding source studied in detail.

Composite cross sections for the backwater analysis of Boardman River were obtained from third order field surveys and stereo compilation from aerial photography flown in January 1980, at a scale of 1:9600; underwater portions of the cross sections were field surveyed. All bridges and culverts were field measured to obtain elevation data and structural geometry.

Valley cross section data, bridge and culvert equation data and structural geometry included in the 1973 SCS analysis of the Kid's Creek watershed were obtained from the SCS office in East Lansing, Michigan and used in this study for the hydraulic analysis of Kid's Creek and Tributary A. A recently completed bridge and culvert replacement program on Kid's Creek and Tributary A has changed the hydraulic carrying capacity of the streams since 1973. Third order field surveys were conducted in 1980 to obtain current bridge and culvert elevation data and structural geometry where replacement has occurred, as determined through field reconnaissance.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles. For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the Flood Boundary and Floodway Map.

Channel roughness factors (Manning's "n"), used in the hydraulic computations, were chosen by engineering judgment and based on field observations of the streams and flood plain areas. The roughness values for the main channel of the Boardman River is 0.03 with overbank roughness values ranging from 0.04 to 0.06 for all floods. Roughness values for the main channel of Kid's Creek and Tributary A range from 0.03 to 0.04 and from 0.028 to 0.035, respectively, with overbank roughness values ranging from 0.035 to 0.055 and from 0.036 to 0.045, respectively for all floods.

Water-surface elevations of the selected recurrence intervals were computed through use of the COE HEC-2 step-backwater computer program (Reference 14). Starting water-surface elevations for the Boardman River were based on Grand Traverse Bay normal pool elevation. For Kid's Creek and Tributary A, the starting water-surface elevations were calculated using the slope-area method. For Kid's Creek, studied by approximate methods, normal depth calculations and two-foot contour interval mapping were used in the analyses.

For Mitchell Creek, the water-surface profiles were developed using the SCS computer program, WSP-2 (Reference 1).

Figures 8-15 show the estimated 100- and 500-year flood levels at selected locations on Boardman River, Kid's Creek and Tributary A.

Flood profiles were drawn showing the computed water-surface elevations for floods of the selected recurrence intervals.

The hydraulic analyses for this study are based only on the effects of unobstructed flow. The flood elevations as shown on the profiles are, therefore, considered valid only if hydraulic structures, in general, remain unobstructed and if channel and overbank conditions remain essentially the same as ascertained during this study.

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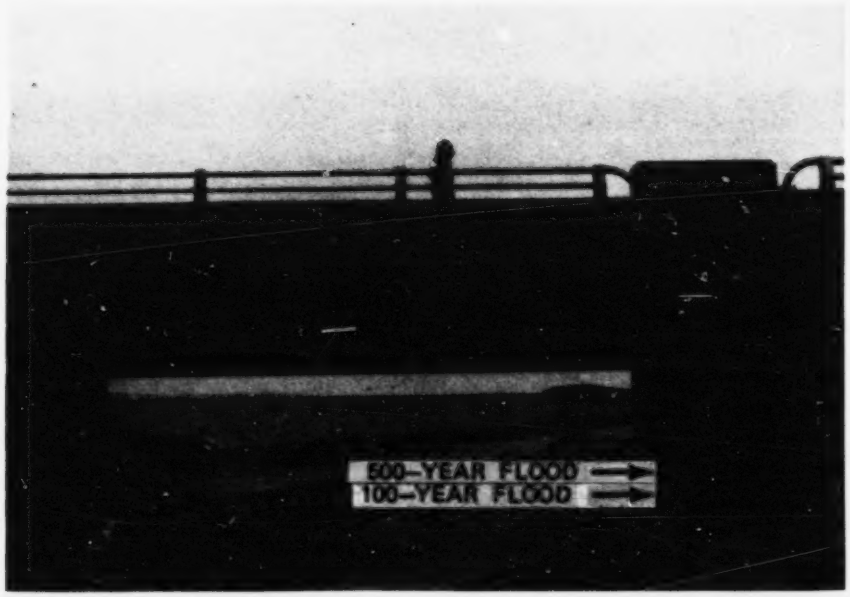

FIGURE 8 - The 100- and 500-year flood levels at the upstream face of Grandview Parkway bridge over the Boardman River, at the outlet to Grand Traverse Bay. (June 18, 1980)

FIGURE 9 - The 100- and 500-year flood levels at the upstream face of Front Street bridge over the Boardman River. (June 18, 1980)

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FIGURE 10 - The 100- and 500-year flood levels at the downstream face of culvert at the southeast corner of intersection of Front and Oak Streets on Kid's Creek. (June 18. 1980)

FIGURE 11 - The 100- and 500-year flood levels are at the downstream face of Front Street bridge over Kid's Creek at west crossing. Photo taken in June 1980 when road was closed for culvert enlargement.

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FIGURE 12 - The 100- and 500-year flood levels at the upstream face of Cedar Street (north crossing) over Kid's Creek. (June 10, 1980)

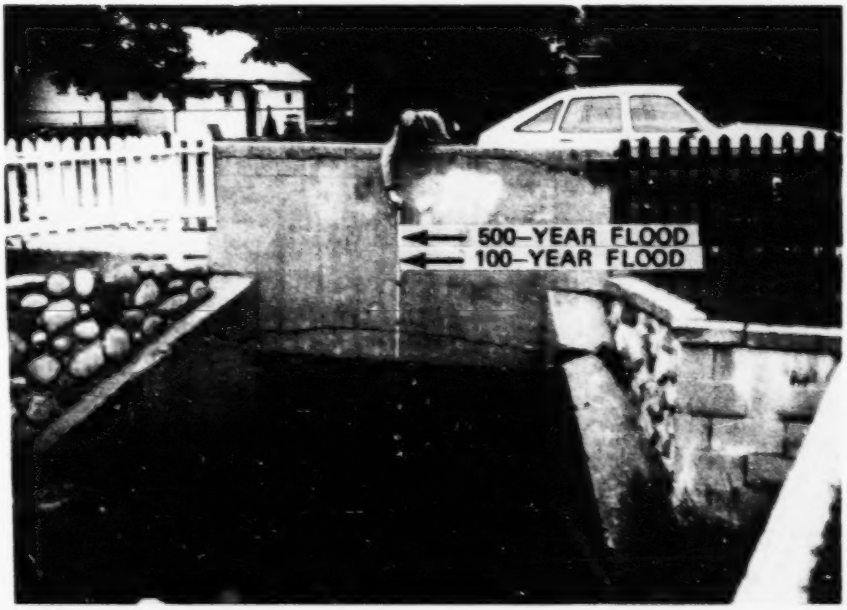

FIGURE 13 - The 100- and 500-year flood levels at the upstream face of Seventh Street bridge over Kid's Creek. (June 10, 1980)

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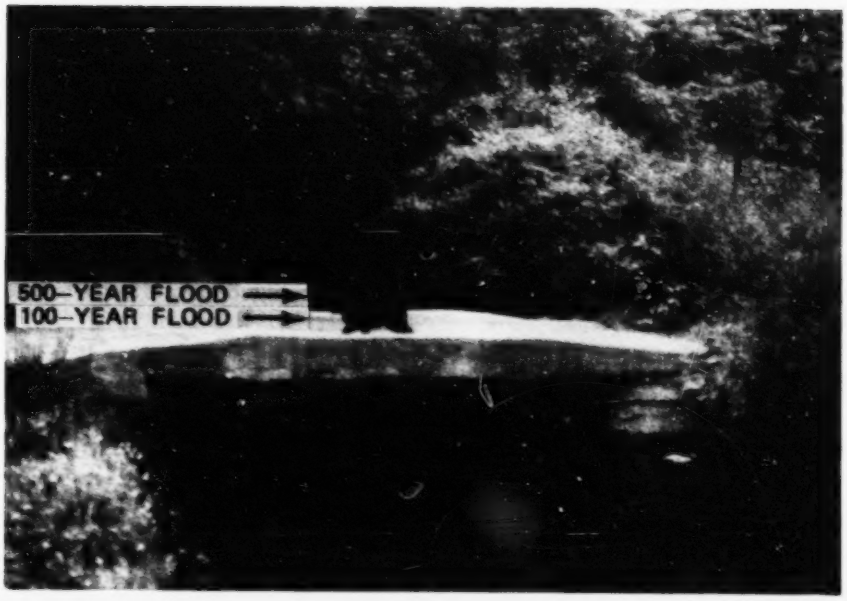

FIGURE 14 - The 100- and 500-year flood levels are at the downstream face of private bridge over Kid's Creek, approximately 50 feet downstream of Cedar Street south crossing. (June 18, 1980) July 1972 flood level at low chord (See Figures 2 and 3)

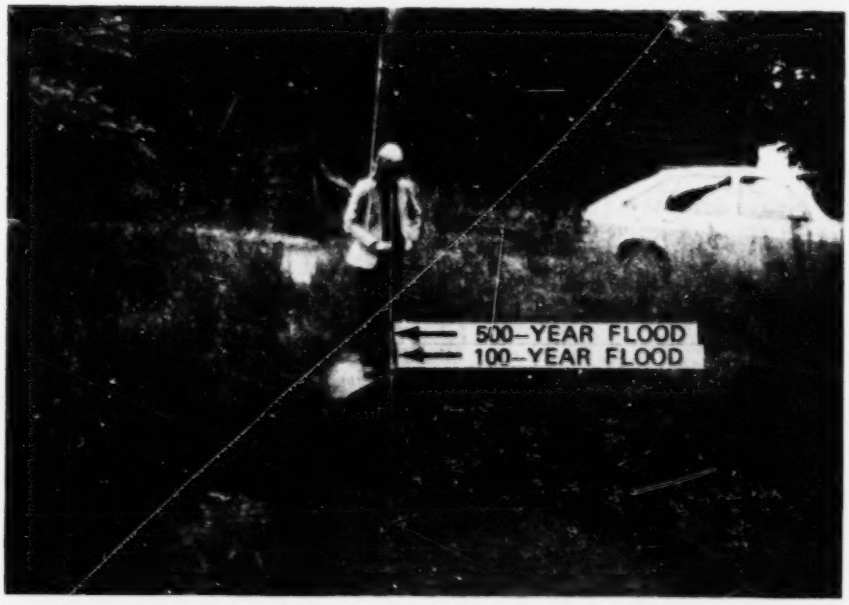

FIGURE 15 - The 100- and 500-year flood elevations at the downstream face of culvert on Tributary A, at alley connecting Madison and Beaumont Streets, south of Front Street. (June 18, 1980)

All elevations are referenced from National Geodetic Vertical Datum of 1929 (NGVD); elevation reference marks used in the study are shown on the maps.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The National Flood Insurance Program encourages state and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance Study includes a flood boundary map designed to assist communities in developing sound flood plain management measures.

4.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by FEMA as the base flood for purposes of flood plain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the boundaries of the 100-year and the 500-year floods have been delineated using the elevations determined at each cross section; between cross sections the boundaries were interpolated using topographic maps at scales of 1:1200 and 1:2400 with a contour interval of two feet (Reference 15).

For the portion of Kid's Creek studied by approximate methods, the boundary of the 100-year flood was developed from normal depth calculations based upon information obtained from field reconnaissance and topographic maps referenced above.

The boundaries of the 100- and 500-year floods are shown on the Flood Boundary and Floodway Map. Small areas within the flood boundaries may lie above the flood elevations and, therefore, not be subject to flooding; owing to lack of detailed topographical information or to limitations of the map scale, such areas are not shown. In cases where the 100-year and the 500-year flood boundaries are close together, only the 100-year boundary has been shown.

4.2 Floodways

Encroachment on flood plains, such as artificial fill, reduces the flood-carrying capacity, increases the flood heights of streams, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood is divided into a floodway and a floodway fringe. The floodway is the channel of a stream plus any adjacent flood plain areas that must be kept free of encroachment in order

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that the 100-year flood may be carried without substantial increases in flood heights. Minimum standards of FEMA limit such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced. In Michigan though, under Michigan Act 245, Public Acts of 1929, as amended by Act 167, Public Acts of 1968 (Reference 16), encroachment in the flood plain is limited to that which will cause only an insignificant increase in flood heights. Thus, at the recommendation of the Bureau of Water Management, a floodway having no more than a 0.1-foot surcharge has been delineated for this study.

The floodways presented in this study were computed on the basis of equal conveyance reduction from each side of the flood plain. The results of these computations were tabulated at selected cross sections for each stream segment for which a floodway was computed (Table 3). No floodways were computed for Mitchell and East Branch Mitchell Creeks.

As shown on the Flood Boundary and Floodway Map, the floodway widths were determined at cross sections; between cross sections, the boundaries were interpolated. In cases where the boundaries of the floodway and the 100-year flood are either close together or collinear, only the floodway boundary has been shown.

The area between the floodway and the boundary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood more than 0.1 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 16.

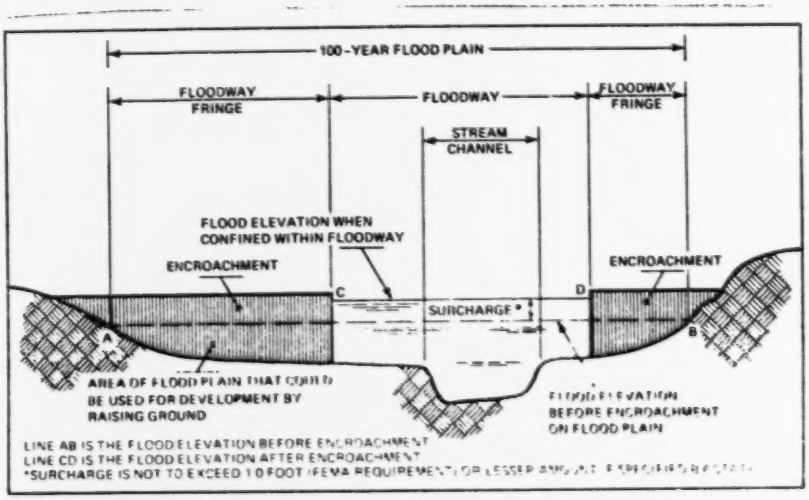
100-YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE *
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE AB IS THE FLOOD ELEVATION BEFORE ENCROACHMENT
LINE CD IS THE FLOOD ELEVATION AFTER ENCROACHMENT
*SURCHARGE IS NOT TO EXCEED 1.0 FOOT (FEMA REQUIREMENT) OR LESSER AMOUNT PRESCRIBED BY STATE

FIGURE 16 - Floodway Schematic

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
BOARDMAN RIVER								
A	330	74	306	5.9	584.0	579.5[2]	579.6	0.1
B	885	70	327	5.5	584.0	580.7[2]	580.7	0.0
C	1450	54	302	6.0	584.0	581.6[2]	581.6	0.0
D	1934	58	384	4.7	584.0	582.4[2]	582.4	0.0
E	2175	54	307	5.9	584.0	582.6[2]	582.6	0.0
F	2565	79	535	3.4	584.0	583.4[2]	583.4	0.0
G	3125	72	466	3.9	584.0	583.8[2]	583.8	0.0
H	3580	69	438	4.1	584.1	584.1	584.1	0.0
I	4006	55	326	5.6	584.4	584.4	584.4	0.0
J	4340	94	619	2.9	585.0	585.0	585.0	0.0
K	4980	72	503	3.6	585.2	585.2	585.2	0.0
L	5485	102	694	2.6	585.4	585.4	585.4	0.0
M	5790	116	933	1.9	585.5	585.5	585.5	0.0

[1]FEET ABOVE MOUTH
[2]ELEVATIONS WITHOUT CONSIDERING BACKWATER EFFECT FROM WEST ARM GRAND TRAVERSE BAY

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF TRAVERSE CITY, MI
(GRAND TRAVERSE CO.)

FLOODWAY DATA

BOARDMAN RIVER

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
KID'S CREEK								
A	225	13	49	6.7	587.2	587.2	587.2	0.0
B	500	64	229	1.4	588.7	588.7	588.8	0.1
C	990	55	177	1.9	591.4	591.4	591.4	0.0
D	1460	95	229	1.4	591.6	591.6	591.6	0.0
E	1840	55	165	2.0	594.7	594.7	594.7	0.0
F	2330	50	141	2.3	597.5	597.5	597.5	0.0
G	2620	39	92	3.6	597.7	597.7	597.7	0.0
H	2875	100	212	1.6	598.4	598.4	598.5	0.1
I	3119	120	279	1.2	598.6	598.6	598.7	0.1
J	3370	100	354	0.9	598.8	598.8	598.9	0.1
K	3686	80	134	2.5	599.1	599.1	599.1	0.0
L	3885	50	77	4.3	600.2	600.2	600.2	0.0
M	4160	60	251	1.3	601.9	601.9	601.9	0.0
N	4530	60	278	1.2	603.8	603.8	603.8	0.0

[1]FEET ABOVE MOUTH

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF TRAVERSE CITY, MI
(GRAND TRAVERSE CO.)

FLOODWAY DATA

KID'S CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
TRIBUTARY A								
A	90	13	37	4.0	603.8	601.0[2]	601.1	0.1
B	790	16	40	3.7	603.8	602.8[2]	602.9	0.1
C	1325	60	103	1.4	608.1	608.1	608.1	0.0
D	1885	11	30	4.9	610.4	610.4	610.5	0.1
E	2255	22	76	1.1	615.3	615.3	615.3	0.0
F	2335	33	89	1.0	615.3	615.3	615.3	0.0
G	2476	50	113	0.7	615.3	615.3	615.3	0.0
H	2855	10	18	4.7	615.5	615.5	615.6	0.1
I	2955	11	37	2.3	619.1	619.1	619.2	0.1
J	3000	13	16	5.3	620.5	620.5	620.5	0.0
K	3183	10	22	3.8	623.1	623.1	623.1	0.0
L	3285	5	11	7.8	623.1	623.1	623.2	0.1
M	3330	10	32	2.7	625.4	625.4	625.4	0.0
N	3430	10	14	6.3	625.6	625.6	625.6	0.0

[1]FEET ABOVE CONFLUENCE WITH KID'S CREEK
[2]ELEVATIONS WITHOUT CONSIDERING BACKWATER EFFECT FROM KID'S CREEK

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF TRAVERSE CITY, MI
(GRAND TRAVERSE CO.)

FLOODWAY DATA

TRIBUTARY A

The floodways in this report are recommended to local agencies as minimum standards that can be adopted or that can be used as a basis for additional studies.

5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, FEMA has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors (FHF), and flood insurance zone designations for each flooding source affecting the City of Traverse City.

5.1 Reach Determinations

Reaches are defined as lengths of watercourses having relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference does not have a variation greater than that indicated in the following table for more than 20 per cent of the reach.

Average Difference Between 10- and 100-year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

The locations of the reaches determined for the City of Traverse City are shown on the Flood Profiles and are summarized in Table 4, "Flood Insurance Zone Data."

5.2 Flood Hazard Factors

The FHF is used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHFs are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations expressed to the nearest 0.5 foot, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year flood water-surface elevations is greater than 10.0 feet, accuracy for the FHF is to the nearest foot.

5.3 Flood Insurance Zones

After the determination of reaches and their respective FHFs, the entire incorporated area of the City of Traverse City was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations:

Zone A:	Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate methods; no base flood elevations are shown or FHFs determined.
Zones A1-A4:	Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations are shown, and zones subdivided according to FHF.
Zone B:	Areas between the Special Flood Hazard Area and the limits of the 500-year flood, including areas of the 500-year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; or areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.
Zone C:	Areas of minimal flooding.

Table 4, "Flood Insurance Zone Data," summarizes the flood elevation differences, FHFs, flood insurance zones, and base flood elevations for each flooding source studied in detail in the community.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for the City of Traverse City is, for insurance purposes, the principal result of the Flood Insurance Study. This map (published separately) contains the official delineation of flood insurance zones and base flood elevation lines. Base flood elevation lines show the locations of the expected whole-foot water-surface elevations of the base (100-year) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by FEMA.

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION[3] (NGVD)
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
BOARDMAN RIVER							
REACH 1	0002	–1.1	–0.3	0.9	010	A2	VARIES–SEE MAP
BOARDMAN LAKE							
REACH 1	0002,0004	–1.1	–0.4	0.8	010	A2	592
WEST ARM GRAND TRAVERSE BAY							
REACH 1	0002,0003	–1.3	–0.3	0.7	015	A3	584
EAST ARM GRAND TRAVERSE BAY							
REACH 1	0003	–1.3	–0.3	0.7	015	A3	584

[1]FLOOD INSURANCE RATE MAP PANEL
[2]WEIGHTED AVERAGE
[3]ROUNDED TO NEAREST FOOT

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF TRAVERSE CITY, MI
(GRAND TRAVERSE CO.)

FLOOD INSURANCE ZONE DATA

BOARDMAN RIVER - BOARDMAN LAKE -
WEST ARM GRAND TRAVERSE BAY - EAST ARM GRAND TRAVERSE BAY

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION[3] (NGVD)
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
KID'S CREEK							
REACH 1	0002	–1.5	–0.4	1.0	015	A3	VARIES–SEE MAP
REACH 2	0002	–2.0	–0.7	0.6	020	A4	VARIES–SEE MAP
MITCHELL CREEK							
REACH 1	0005	–2.1	–0.6	0.8	020	A4	VARIES–SEE MAP
REACH 2	0005	–1.0	–0.3	0.6	010	A2	VARIES–SEE MAP
REACH 3	0005	–0.7	–0.2	0.2	005	A1	VARIES–SEE MAP
EAST BRANCH MITCHELL CREEK							
REACH 1	0005	–2.0	–0.8	0.8	020	A4	VARIES–SEE MAP
REACH 2	0005	–1.0	–0.4	0.5	010	A2	VARIES–SEE MAP
TRIBUTARY A							
REACH 1	0002	–0.9	–0.2	0.3	010	A2	VARIES–SEE MAP

[1]FLOOD INSURANCE RATE MAP PANEL
[2]WEIGHTED AVERAGE
[3]ROUNDED TO NEAREST FOOT

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF TRAVERSE CITY, MI
(GRAND TRAVERSE CO.)

FLOOD INSURANCE ZONE DATA

KID'S CREEK - MITCHELL CREEK -
EAST BRANCH MITCHELL CREEK - TRIBUTARY A

6.0 OTHER STUDIES

In February 1977, the COE prepared a Report on Great Lakes Open-Coast Flood Levels (Reference 11). In 1973, the SCS, in cooperation with the Grand Traverse Soil Conservation District, published the following report, Kid's Creek Watershed Land and Water Resource Inventory and Evaluation (Reference 6). The information contained in both of these reports was utilized with this study. No other studies containing flood elevations were found to exist at this time for the City of Traverse City.

A "Flood Hazard Study" was prepared for Mitchell Creek by the SCS (Reference 1) and is in agreement with this study.

A Flood Hazard Boundary Map has been published for the community (Reference 17). The differences between the Flood Hazard Boundary Map and this study are justified due to the more detailed nature of this Flood Insurance Study.

This report either supersedes or is compatible with all previous studies published on streams studied in this report and should be considered authoritative for the purposes of the National Flood Insurance Program.

7.0 LOCATION OF DATA

Information concerning the pertinent data used in preparation of this study can be obtained by contacting the Natural and Technological Hazards Division, Federal Emergency Management Agency, 300 South Wacker Drive, (24th Floor), Chicago, Illinois 60606.

8.0 REFERENCES AND BIBLIOGRAPHY

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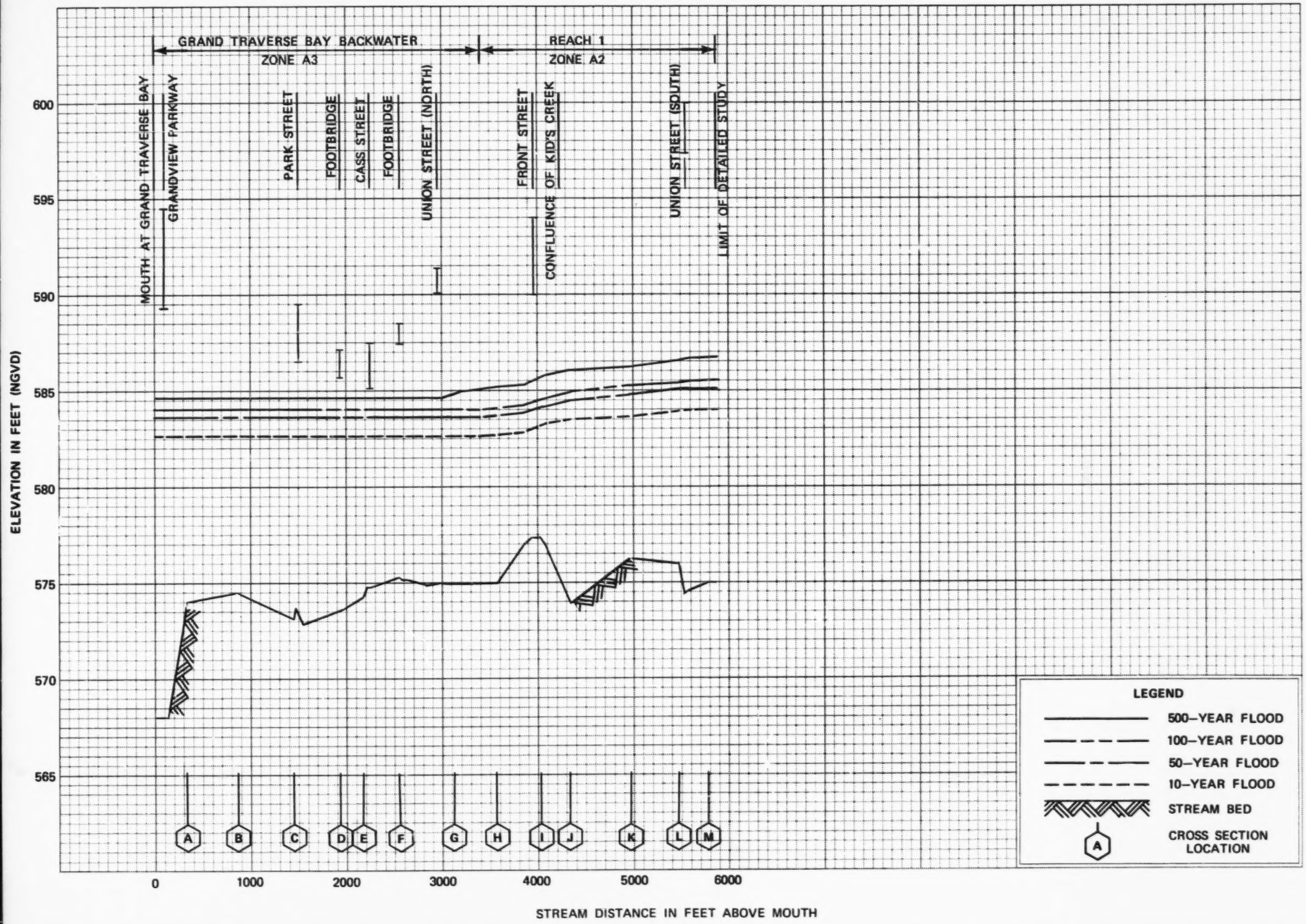

FLOOD PROFILES

BOARDMAN RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF TRAVERSE CITY, MI
(GRAND TRAVERSE CO.)

01P

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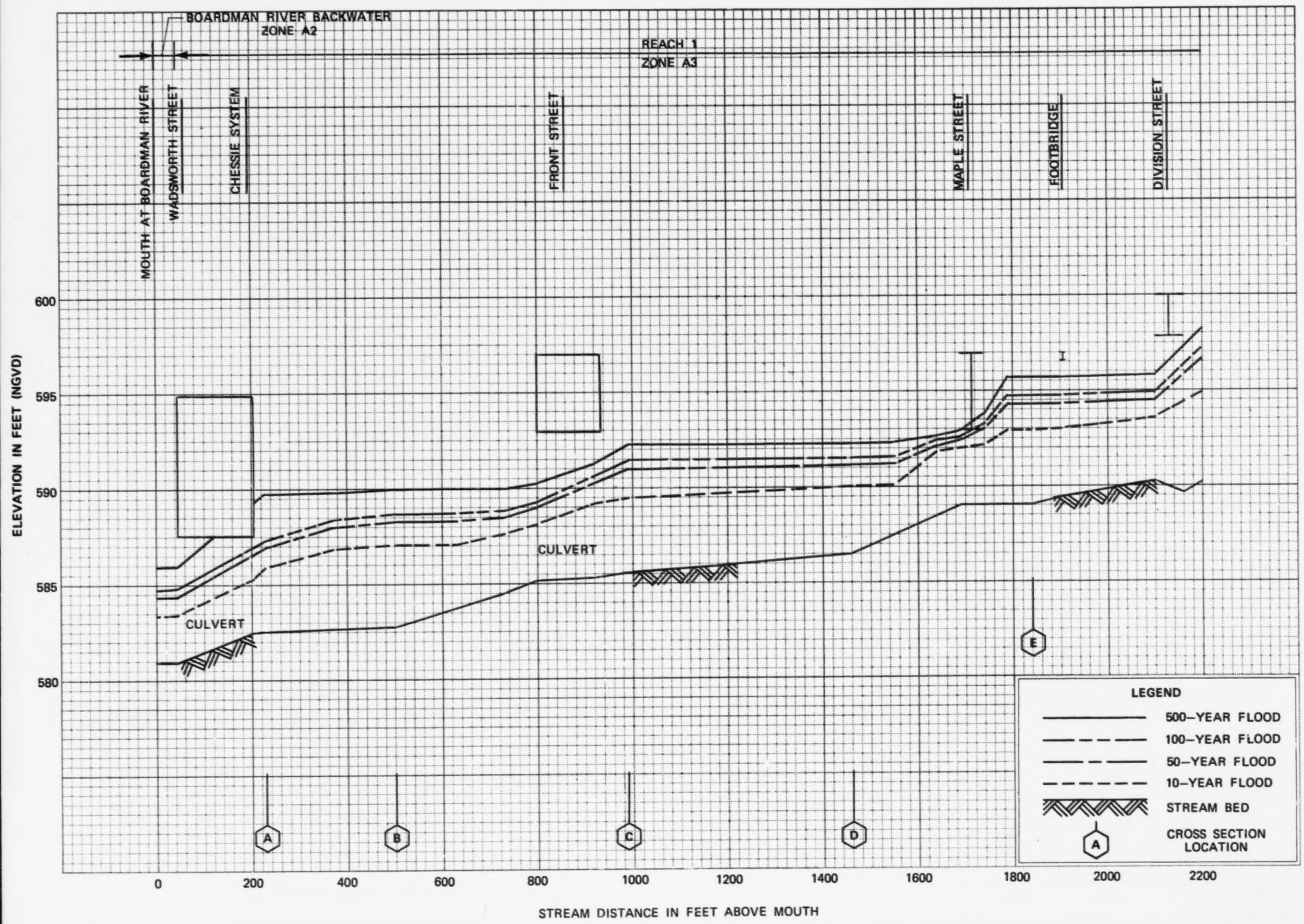

FLOOD PROFILES

KID'S CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF TRAVERSE CITY, MI
(GRAND TRAVERSE CO.)

02P

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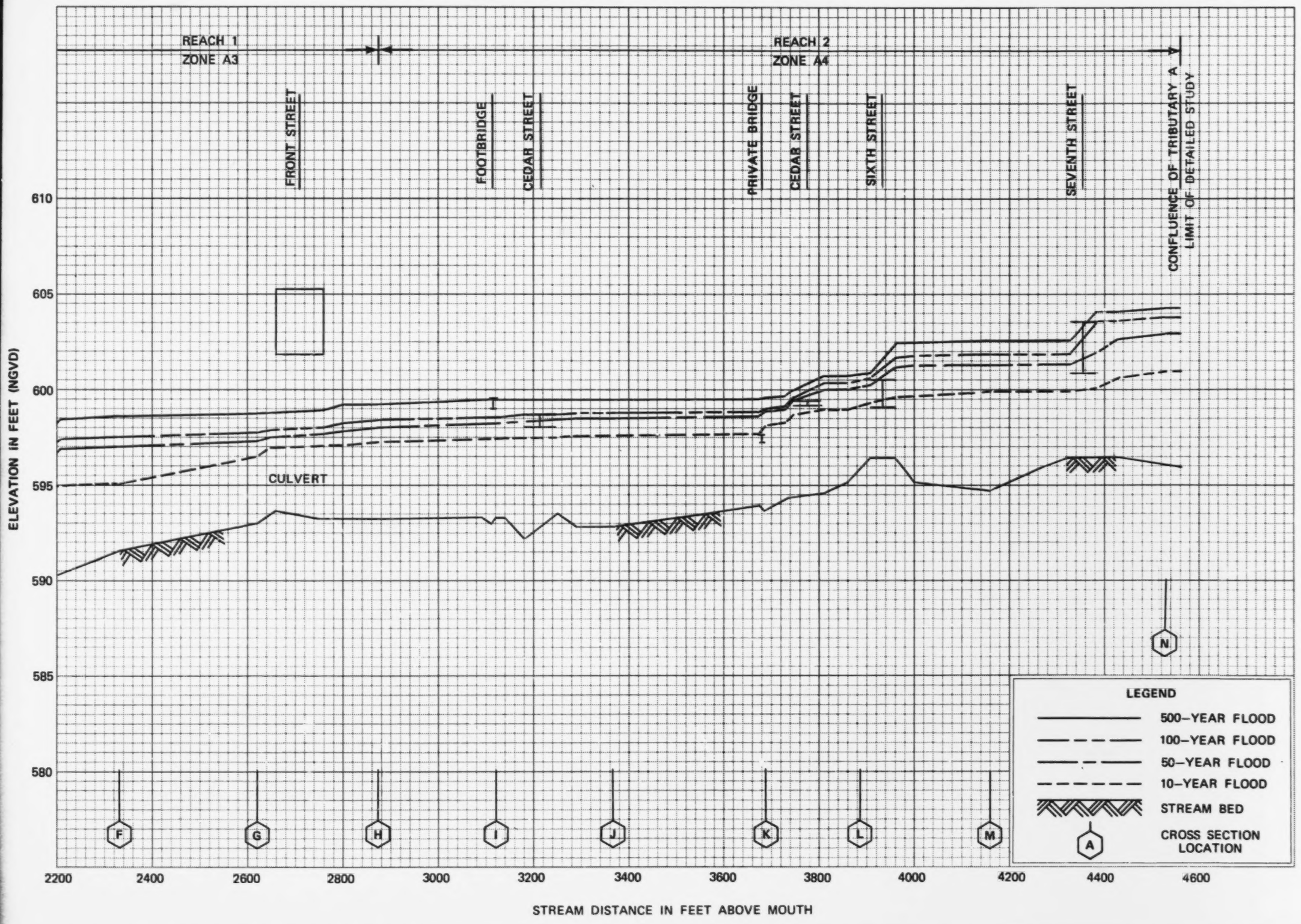

FLOOD PROFILES

KID'S CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF TRAVERSE CITY, MI
(GRAND TRAVERSE CO.)

03P

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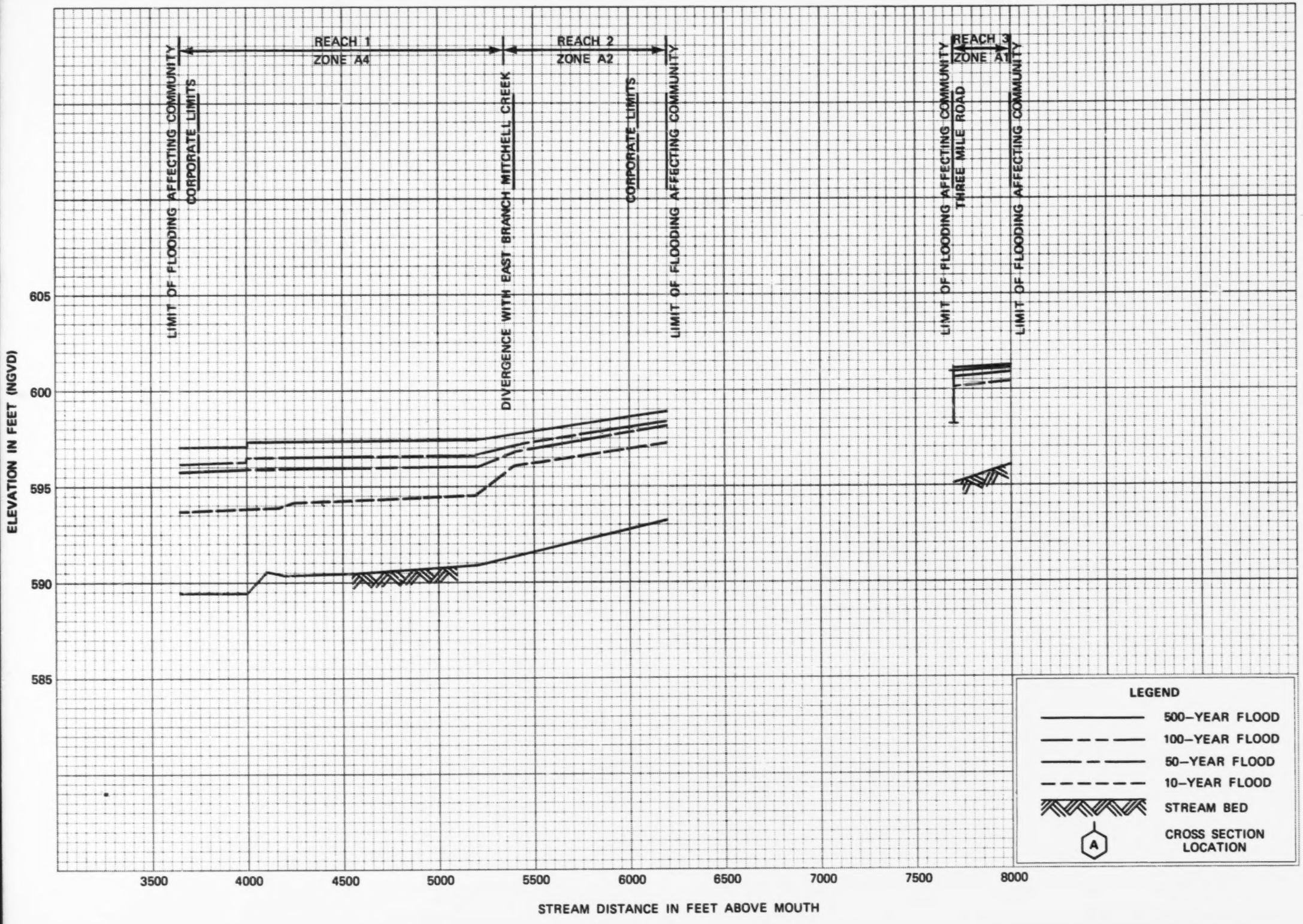

FLOOD PROFILES

MITCHELL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF TRAVERSE CITY, MI
(GRAND TRAVERSE CO.)

04P

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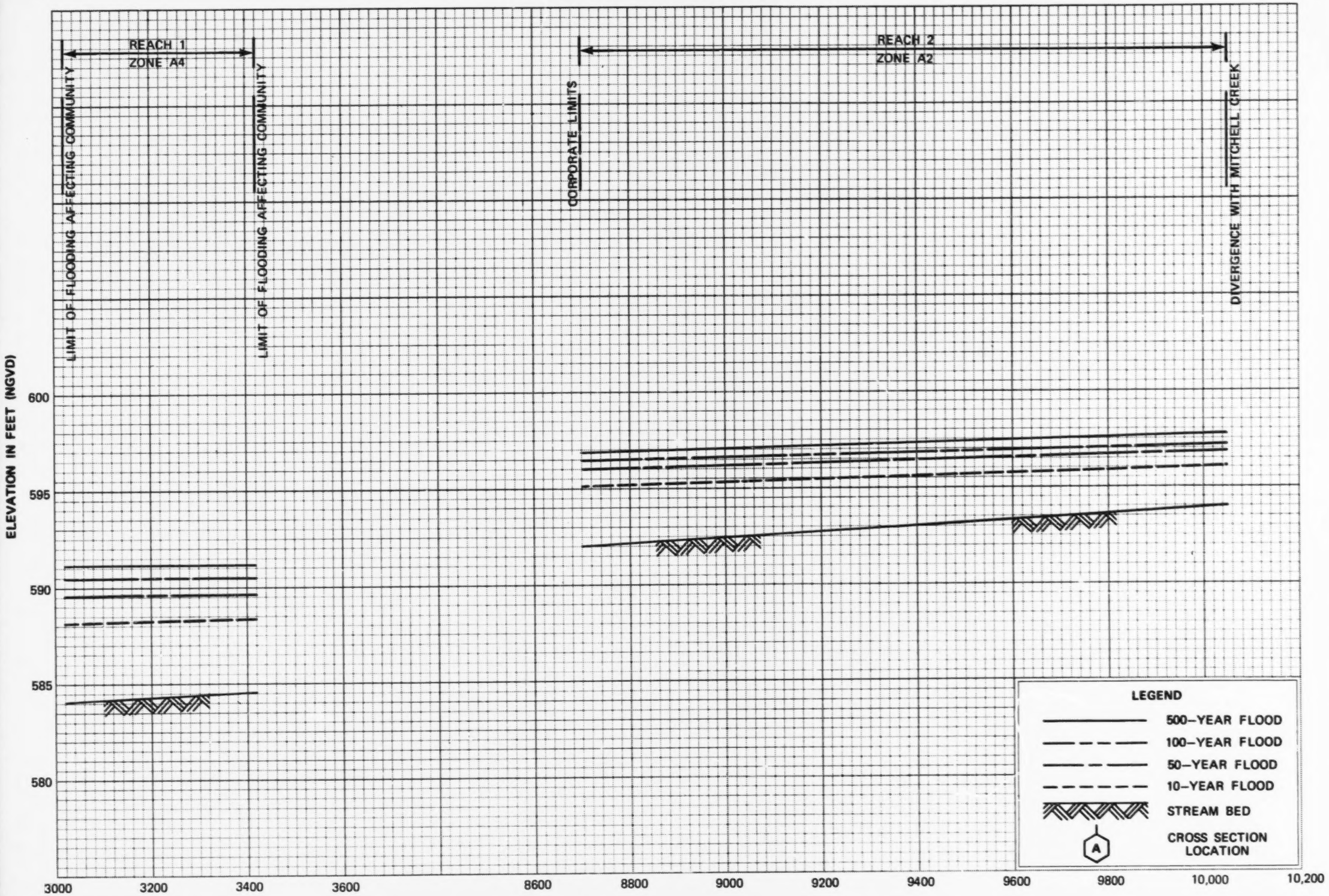


FLOOD PROFILES

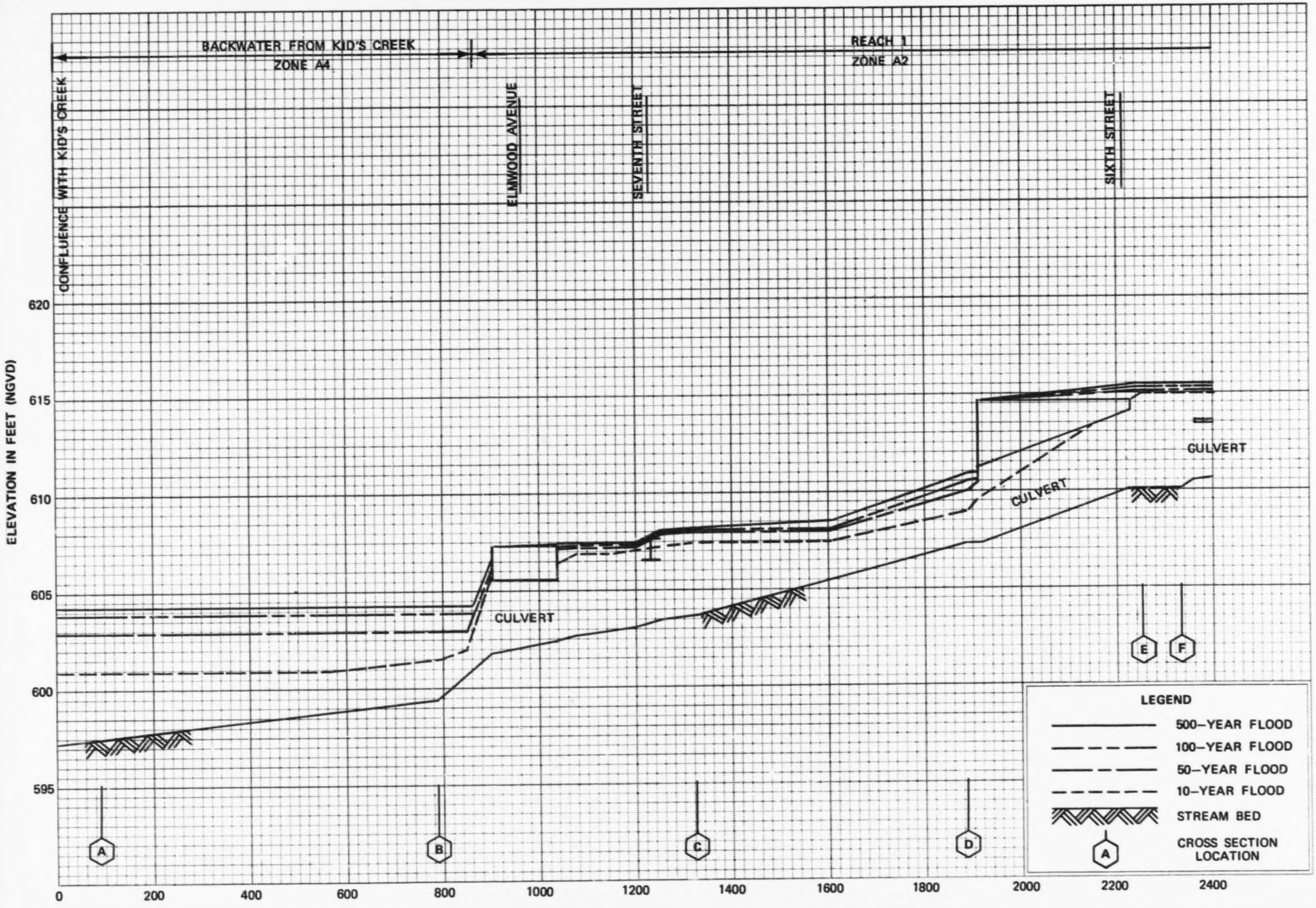
EAST BRANCH MITCHELL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF TRAVERSE CITY, MI
(GRAND TRAVERSE CO.)

05P

BEST DOCUMENT AVAILABLE



FLOOD PROFILES

TRIBUTARY A

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF TRAVERSE CITY, MI
(GRAND TRAVERSE CO.)

06P

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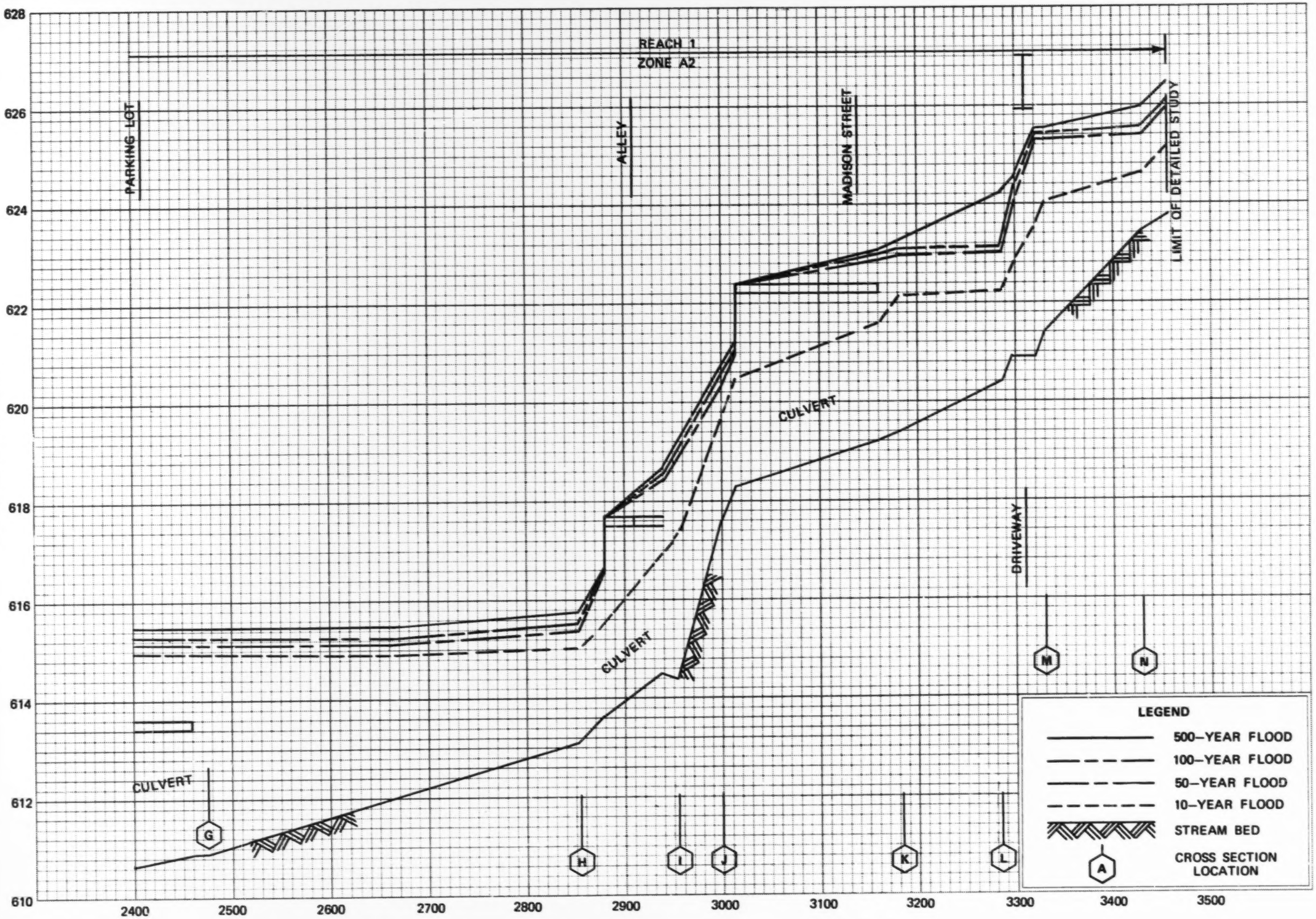

FLOOD PROFILES

TRIBUTARY A

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF TRAVERSE CITY, MI
(GRAND TRAVERSE CO.)

07P